Investigating PMS populations in the Large Magellanic Cloud

Viktor Zivkov, Joana M. Oliveira, Monika G. Petr-Gotzens, and the VMC team
(Zivkov et al., submitted)

Introduction

Using near-infrared photometry from the VISTA Survey of the Magellanic Clouds (VMC; Cioni et al. 2011), we aim to characterise PMS populations down to ~1$M_\odot$ across the full spatial extent of the Magellanic Cloud system. Due to its moderate distance of 50 kpc (e.g. de Grijs et al. 2014) the Large Magellanic Cloud (LMC) offers a unique opportunity to study star formation from a galaxy-wide scale down to individual intermediate/low mass stars. Being metal-poor (e.g. Besla et al. 2012) it also provides insight into an environment similar to that of the early Universe. We present our method and the results from applying it onto a 1.5 deg^2 (~1.2 kpc^2) pilot field located in the LMC (Zivkov et al., submitted).

Method

- Divide the pilot field into a regular spatial grid.
- Construct a suitable control field for every grid element.
- Create colour magnitude diagrams (CMDs) of both grid element and control field based on PSF photometry catalogues (Rubele et al. 2012, 2015).
- Apply reddening and completeness corrections on the control field population to match the properties of the grid-element.
- Transform the CMDs into continuous density maps (Hess-CMDs).
- Subtract the control field Hess-CMD from the grid elements Hess-CMD to create a residual-CMD.
- Over-densities in the residual-CMD indicate populations mostly absent in the control field. They are used to classify the stellar population of the grid element.

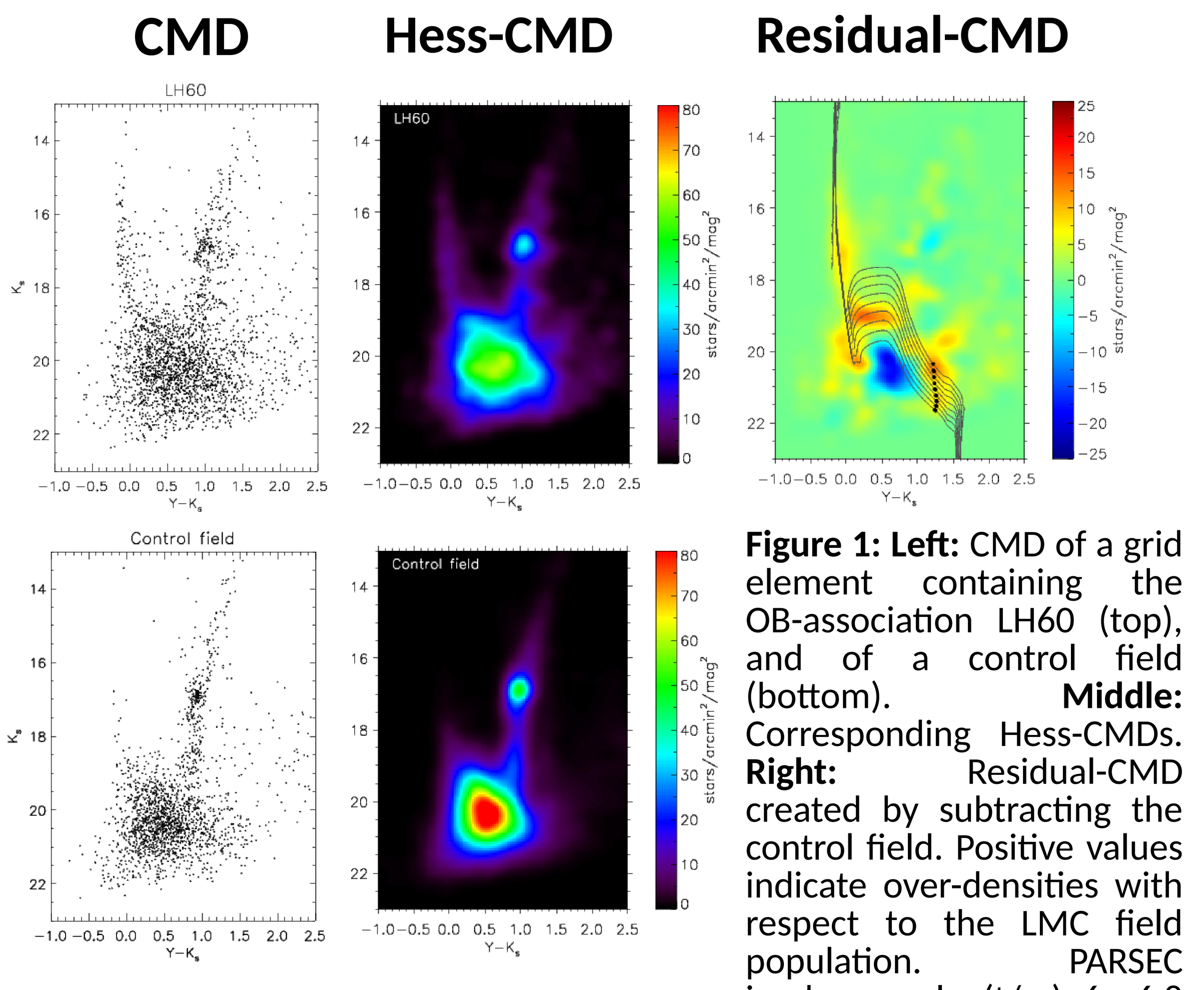
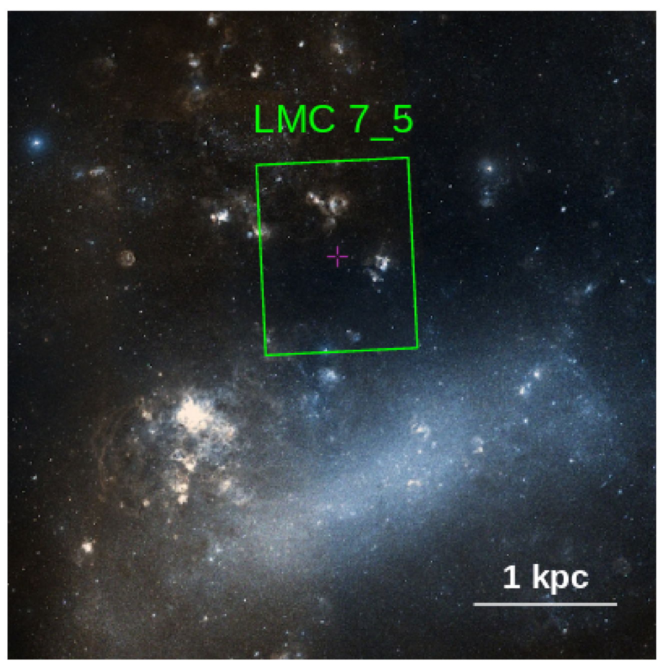


Figure 1: Left: CMD of a grid element containing the OB-association LH60 (top), and of a control field (bottom). **Middle:** Corresponding Hess-CMDs. **Right:** Residual-CMD created by subtracting the control field. Positive values indicate over-densities with respect to the LMC field population. PARSEC isochrones log(t/yr)=6—6.8 are also shown (Bressan et al. 2012). The circles show the theoretical positions of a 1$M_\odot$ PMS star.

Results



The pilot field

We chose an area located ~1.7° to the North of the LMC bar. It contains with N44 and N51 two large star forming complexes (Carlson et al. 2012) and also contains numerous clusters across a wide age range from 1Myr – 1Gyr (e.g. Popescu et al. 2012). Hence, it provides a variety of populations, making it ideal for testing purposes.

PMS populations and their distribution

Overall, 208 out of 11250 grid elements in the pilot field have a significant PMS contribution. 124 of them also contain a population of young upper main-sequence (UMS) stars (UMS+PMS elements hereafter). Calculations using the over-densities in the residuals give a total of ~2250 PMS candidates. Based on evolutionary models (Bressan et al. 2012) their likely mass range is between 1$M_\odot$ and 4$M_\odot$.

The PMS distribution is non-uniform and concentrates mostly in a few major SF regions (Fig.2 left panel). UMS+PMS elements show a particularly high degree of clustering. In contrast, PMS-only elements are usually found in the outskirts of populous UMS+PMS groupings or isolated. Figure 2 (right panel) shows PMS density contours overplotted onto an RGB image (350µm, 160µm, 70µm). Most PMS candidates are located in areas with intense far-infrared emission, indicating that they follow the dust distribution.

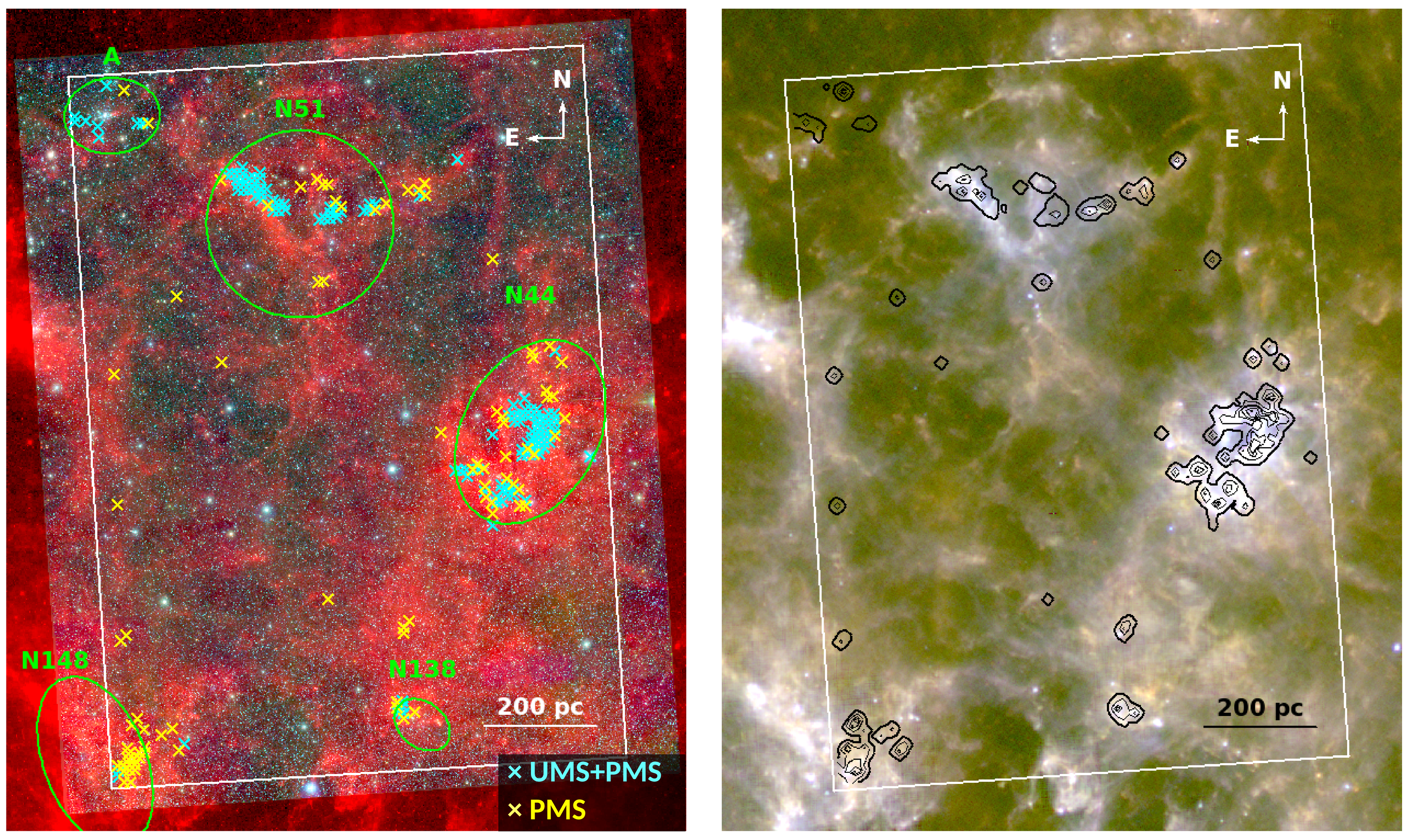


Figure 2: Left: Three colour composite of the pilot field (R:8µm, G: 2.15µm, B:1.02µm). Cyan crosses mark the location of grid elements that contain UMS and PMS stars; yellow crosses indicate elements populated only by PMS stars. Prominent SF-regions are labelled. **Right:** Three colour composite in the far-infrared (R:350µm, G: 160µm, B:70µm; Meixner et al. 2006, 2013). Black lines are PMS density contours derived from the residuals. The outermost contour represents n_{PMS}=2.4 stars arcmin^{-1}, with every subsequent contour indicating an increase by 3 × 2.4 stars arcmin^{-1}.

Discussion and summary

- In total ~2250 PMS candidates between ~1$M_\odot$–4$M_\odot$ are detected in the pilot field (~1.2 kpc^2), with the most populous being the N44 SF-complex (~1000 PMS candidates).
- Based on extensive tests with artificial clusters our method is sensitive to clusters or associations down to ~500$M_\odot$. For ages ≤2Myr the sensitivity increases to a mass limit of ~250$M_\odot$. PMS stars can be identified up to an age of 10Myr.
- Large SF-complexes are hierarchically structured and consist of multiple high stellar density peaks.
- The distribution of the number of PMS stars within young stellar structures can be approximated by a power-law with a slope of -0.86±0.12 (Fig.3). A mass distribution with this slope would be broadly consistent with hierarchical star formation (Elmegreen 2008).

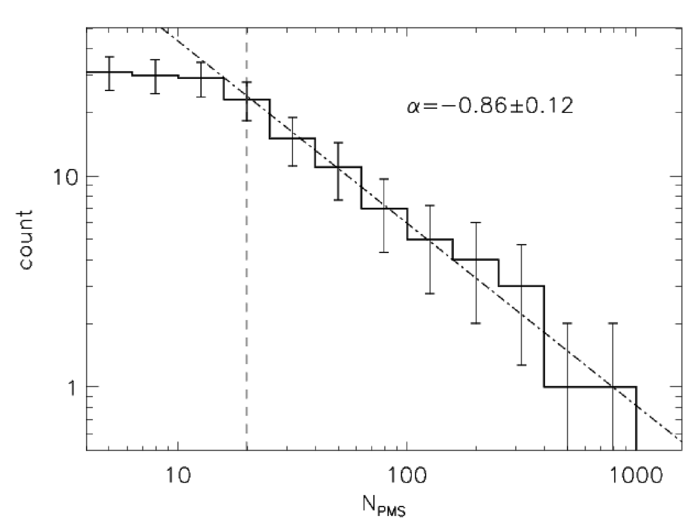


Fig. 3: Cumulative number distribution for the PMS structures (0.2 dex bins). The vertical line indicates the sensitivity limit, the dashed-dotted line represents a power-law. Error bars are Poissonian uncertainties.

Future Work

- Expand the analysis to other areas of the LMC
- Adopt the method onto the Small Magellanic Cloud (larger distance, lower metallicity)
- Use multi-epoch observations in combination with the analysis above to identify young stellar variables and compare their properties with Milky Way variability studies.